

# ***GENERATION IV ROADMAP***

## ***EVALUATION METHODOLOGY***

***Evaluation Methodology Group***

***K. Matsui***

***ICONE10 Meeting***

***April 16, 2002***

# ***Evaluation Methodology Group Charter***

***“Develop a process for the systematic evaluation of the comparative performance of proposed Generation IV concepts against established Generation IV Goals”***



# ***Evaluation Methodology Group (EMG)***

*Deborah Bennett*

*Evelyne Bertel*

*Dennis Bley*

*Douglas Crawford*

*Brent Dixon*

*Michael Golay*

*William Halsey*

*Kazuaki Matsui*

*Keith Miller*

*Per Peterson*

*William Rasin, Co-chair*

*Jordi Roglans, Co-chair*

*Geoffrey Rothwell*

*Thomas Shea*

*Michel Vidard*

*Jean-Claude Yazidjian*

*Los Alamos National Laboratory*

*OECD - Nuclear Energy Agency*

*Buttonwood Consulting, Inc.*

*Argonne National Laboratory*

*Idaho National Engineering and Environmental Laboratory*

*Massachusetts Institute of Technology*

*Lawrence Livermore National Laboratory*

*Institute of Applied Energy, Japan*

*British Nuclear Fuels Ltd., United Kingdom*

*University of California - Berkeley*

*Consultant, formerly with Duke Engineering & Services, Inc.*

*Argonne National Laboratory*

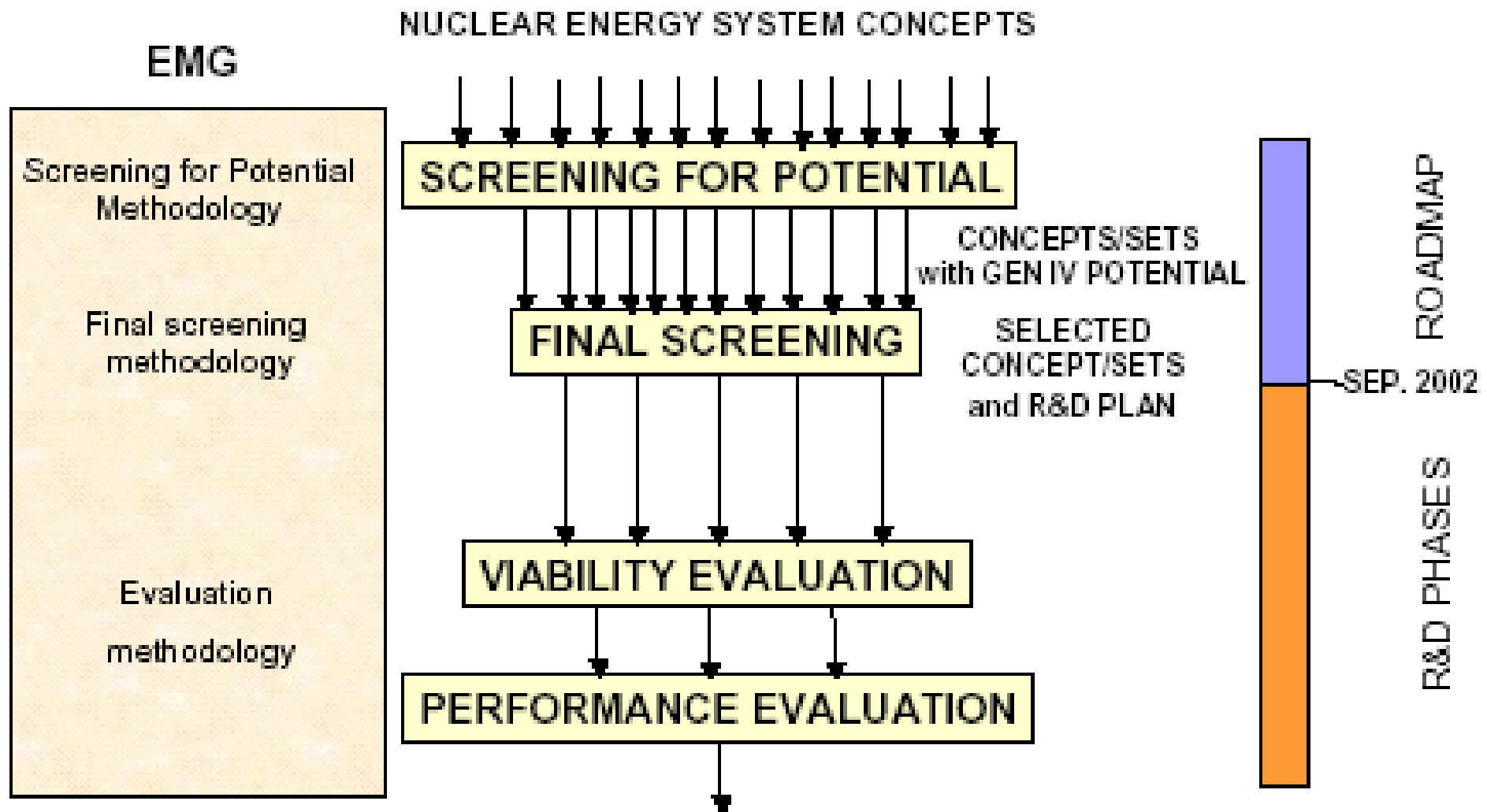
*Stanford University*

*International Atomic Energy Agency*

*Electricite de France, France*

*Framatome, France*

# Evaluation Process

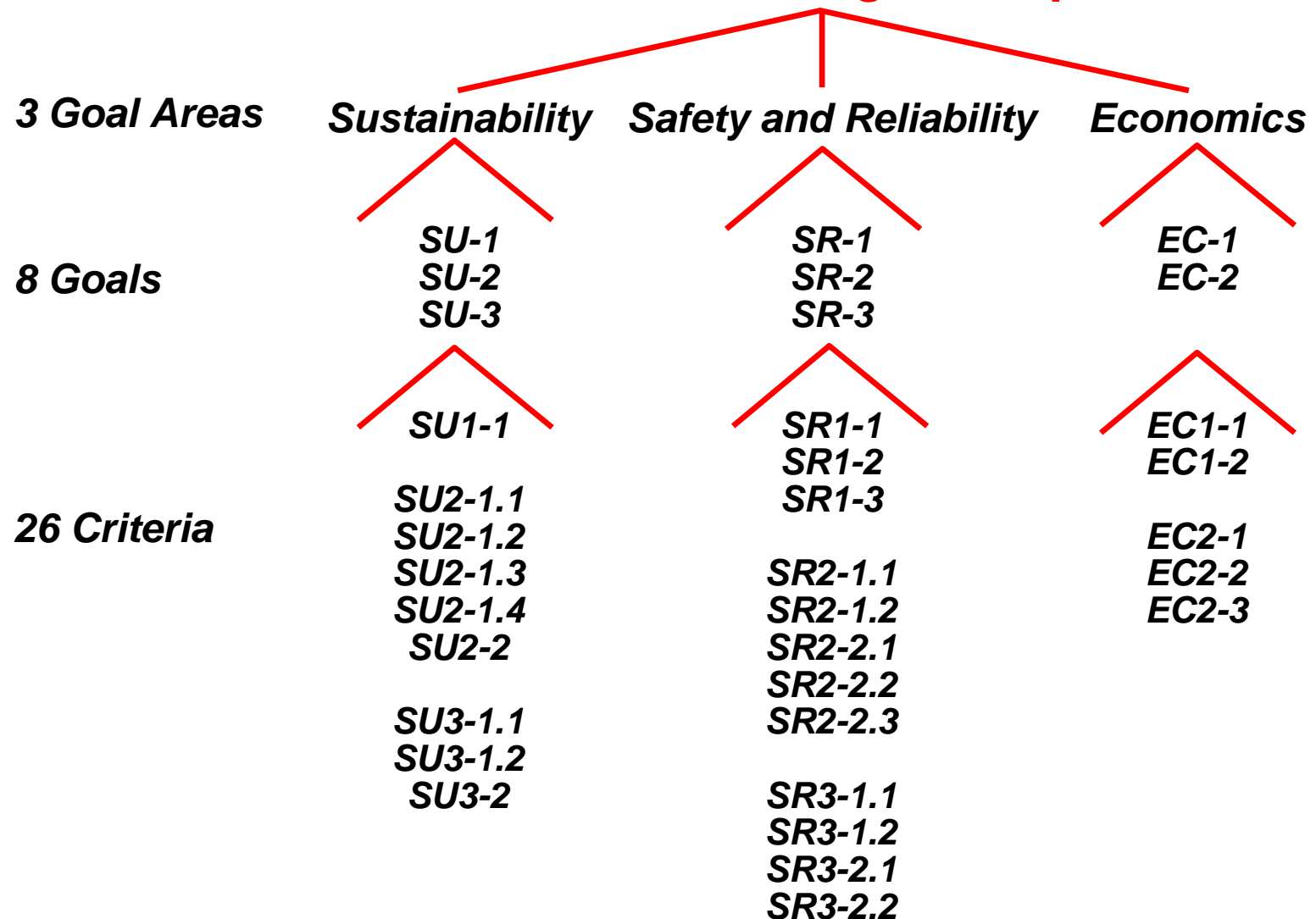


# ***Generation IV's Eight Goals***

- ***Sustainability***
  - ***SU1: Sustainable energy generation***
  - ***SU2: Waste minimization***
  - ***SU3: Proliferation resistance***
- ***Safety and Reliability***
  - ***SR1: Excellence in Safety and Reliability***
  - ***SR2: Low likelihood and degree of core damage***
  - ***SR3: No need for offsite emergency response***
- ***Economics***
  - ***EC1: Life cycle cost advantage***
  - ***EC2: Tolerable financial risk***

# Rollup of Criteria, Goals and Goal Areas

## Most Promising Concepts



# ***Evaluation Methodology***

- ***Establish criteria and metrics for each of the eight goals***
- ***For each criteria establish a scale covering a range of seven possible scores, scored relative to ALWR reference***

Use of fuel resources : final screening metric scale

Much worse than reference	Worse than reference	Slightly worse than reference	Similar to reference	Slightly better than reference	Better than reference	Much better than reference
>300 Mt U feed/GWyr	250-300 Mt U feed/GWyr	200-250 Mt U feed/GWyr	150-200 Mt U feed/GWyr	100-150 Mt U feed/GWyr	10-100 Mt U feed/GWyr	<10 Mt U feed/GWyr

- ***EMG technological judgment used to establish value of criterion scale and how to synthesize the distributed scores***

# ***Evaluation Methodology***

- ***Criteria metrics are weighted but the eight goals within sustainability, safety and reliability, and economics are weighted equally***

## **Sustainability-2: Waste minimization and management**

### **SU2-1 Waste minimization**

Mass of waste	0.2
Volume of waste	0.2
Long-term heat output	0.2
Long-lived radiotoxicity	0.2

- ***EMG was required to propose methods to answer the following questions: Are metrics independent and sufficient and how are metrics combined in a fair manner?***
- ***The EMG desired to create a tool for discrimination, analogous to Multi-Attribute Analysis for decision making***



# **Considerations on Sustainability Goals:**

## **SU-1 - Insights on future fuel cycles**

- ***Achieving sustainability using nuclear systems discussed at Seoul GIF meeting in Summer of 2000. Sustainability requires recycle***
- ***Gen IV Roadmap has conducted extensive studies on impact of different fuel cycles on fuel resources and waste generation***
- ***For some GIF members, advanced fuel cycles that include recycling may need to be reconciled with national non-proliferation policies***
- ***Recycling policy assessments must be performed in the context of the entire fuel cycle, including impact of disposal of fissile material***
- ***Sustainability-1 (fuel resources utilization) must be evaluated in conjunction with the other sustainability goals of waste minimization and proliferation resistance***
- ***Sustainability goals have unique features comparing to other goals***

# **Considerations on Sustainability Goals:**

## **SU-2 - Waste as a sustainability issue**

- ***Waste management raises political and societal problems, more difficult to resolve than its engineering and technical challenges***
- ***One of the primary concerns in waste disposal is long-term radioactive toxicity, which can be reduced with fuel cycles that reduce the amount of actinides sent to disposal sites; such fuel cycles are based on fast-spectrum systems (including fast reactors or accelerator-driven systems for burning minor actinides and long-lived fission products)***
- ***For the time being, spent fuel is being accumulated in large amounts; fuel cycle studies for sustainability must account for the accumulated spent fuel***
- ***Waste management must take international collaboration such as Russian acceptance of SF into account***

# **Considerations on Sustainability Goals:**

## **SU-3 - Proliferation-Resistance is a must**

- ***TOPS; The Technological Opportunities to Increase the Proliferation Resistance of Global Civilian Nuclear Power Systems in 2000***
- ***Additional burdens may be created on non-nuclear weapon countries deploying nuclear energy systems, as well as added responsibilities for nuclear weapon countries***
- ***Present stable situation achieved with IAEA Safeguards activities; but for the nuclear energy share to grow, advanced nuclear systems must facilitate safeguardability to maintain IAEA burden manageable***
- ***Focus should be on the entire fuel cycle, not just on reactors***
  - ***Proliferation risks of fuel cycle facilities must be balanced with risks of disposing spent fuel containing fissile material***
- ***Discussion on International fuel cycle cooperation may be considered to accommodate excess spent fuel***
- ***In addition to proliferation issues, advanced nuclear energy systems must address issues of resistance to terrorism***
- ***How effective will the technical solutions be?***

# ***System Evaluation: a step forward in the selection and development of a Gen IV nuclear energy system***

- ***Evaluation as a tool to identify and formulate a set of common R&D to meet the needs of the participating countries***
- ***Enhance international collaboration, partnership***
- ***Conditions derived from deployment scenarios, mission and country dependent requirements***
- ***Generation IV nuclear development to refresh the old paradigm, under the conditions of scarce resources and public acceptance***
- ***Bringing together overall sustainability issues with national priorities or preferences of GIF countries, such as use of fast reactor programs: Sodium-coolant in Japan, Gas in France and Lead in Russia***
- ***Feasibility of small reactors***
- ***How to set up international partnerships, and how to manage the joint R&D programs***